DOCUMENT RESUME

ED 444 341 EF 005 746

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TITLE	Projecting Costs for School Buildings under Various Growth Scenarios. OSP Technical Reference Document.
INSTITUTION	New Jersey Office of State Planning, Trenton.
REPORT NO	OSP-TR-62
PUB DATE	1990-04-00
NOTE	21p.; Appendices are not included with the electronic version. Cover page varies.
AVAILABLE FROM	Full text: www.state.nj.us/osp/doc/trd/osptr062.pdf.
PUB TYPE	Reports - Descriptive (141)
EDRS PRICE	MF01/PC01 Plus Postage.
DESCRIPTORS	*Cost Estimates; *Educational Facilities Improvement; Elementary Secondary Education; *Enrollment; *Public Schools; School Construction
IDENTIFIERS	*New Jersey

ABSTRACT

A model is presented (part of a larger model for estimating the fiscal impacts associated with growth scenarios) for estimating the cost of new school buildings required by alternative land development plans. A description of the model is presented, along with its equations, and followed by a discussion of the extensions, enhancements, and applications of the Fiscal Impact Model. Appendices provide the organization of the New Jersey School Districts 1984-85, questionnaires used to obtain enrollment and capacity data, public school enrollment by county for 1980, and table of enrollment and capacity by district for 1989-90. (GR)

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Projecting Costs for School Buildings under Various Growth Scenarios

OSP Technical Reports

April 1990

prepared by:
The New Jersey Office of State Planning

EF 005 746

The Preliminny State Development AND Redevelopment Plan

Available at:

www.state.nj.us/osp/doc/trd/osptr062.pdf

Projecting Costs for School Buildings under Various Growth Scenarios

OSP Technical Reference Document 62

N.J. Office of State Planning
33 West State Street
Trenton, NJ 08625
April 1990

This report was written by James Reilly of the Office of State Planning's research unit. The approach was developed by Paul Gottlieb and revised by Mr. Reilly. William Bauer and Mary Housel provided, respectively, research, and typing assistance.

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I. INTRODUCTION

A. Model Purpose

This model was developed to estimate the cost of new school buildings required by alternative land development plans, expressed as alternative municipal-level estimates of population and at-place employment.

This model is one component of a larger model that estimates the fiscal impacts associated with growth scenarios. The other components of the model are: operations and maintenance, population and employment distribution, sewers, and roads.

B. Model Origins

The school component of the Office's first fiscal impact model[1] initially contained a single algorithm for each of the State's Plan's policy areas (tiers) identified in the April 1987 Draft Preliminary State Development and Redevelopment Plan. The cost estimation equation for a single tier was as follows.

School Algorithm (1987 version)

[((SFUT x. 74) + (MFUT x .24)) /27] x SC = Total Capital cost for new classrooms

SFUT = the increase in single family units in the specific tier

MFUT = the increase in multi-family units in the specified tier

SC = cost per classroom

.74 = estimate of pupils per single family dwelling unit

.24 = estimate of pupils per multi-family dwelling unit

27 = number of pupils per classroom

The model was derived from methodologies and analysis reported in The Fiscal Impact Handbook, written by Robert Burchell and David Listokin and published by the Center for Urban Policy Research, part of Rutgers University.[2]

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[1] We are referring here to a capital cost model developed by OSP consultants Wallace, Roberts & Todd, and documented in the OSP Technical Reference Document entitled Comparison of Infrastructure Costs for Alternatives (June 1, 1987, revised January 18, 1988).

[2] Robert W. Brutal and David Listokin, The Fiscal Impact Handbook: Estimating Local Costs and Revenues of Land Development (New Brunswick: Center for Urban Policy Research, 1978)

Several problems were noted about the model. First, the model used student-per-housing multipliers that differed from those recommended by the Fiscal Impact Handbook. Second, the model reported results by tier. In April 1987 Draft Plan, tiers were co-terminus with municipal boundaries. In subsequent revisions to the Draft Plan, tiers did not follow municipal lines. Since municipalities could contain a blend of tiers, it became impossible to aggregate or disaggregate tier results given municipal growth forecasts. Finally, the model's assumptions were insensitive to regional, or local preferences and conditions, such as the preference to send children to public or private schools.

An alternative method then was programmed which adjusted school costs, at a municipal level, according to the anticipated changes in population and city size. Costs in this model reflected actual 1985 municipal expenditures;[3] the cost projection methodology was based on the "Comparable Cities" method developed by Burchell and Listokin.

This second method was abandoned for several reasons. First, while the cost data were specific to New Jersey municipalities, the cost adjustment factors in the model were derived from 1972 national data. The model also was insensitive to demographic changes and its cost base was municipalities, as opposed to school districts.

The OSP model described in this paper represents a district-by-district case study simulation. In the current model, a forecast of public school children is made and categorized by elementary, middle or high school age groups. Each school population then is compared to the district's current school building capacity for that age group. If new facilities are required, the costs are estimated. Finally, all new facility costs are assigned to the municipalities served by the school districts on a population basis.

The OSP model estimates the capital costs required to build new school buildings to accommodate future populations. Operating costs are not included in the model; therefore, cost savings that might accrue from school closures are not reflected. Furthermore, the model contains no information about school building conditions. While many of the State's older school buildings may be in need of substantial repair or replacement , the model does not reflect these needed capital expenditures. It is assumed that such replacement or renovation costs would be needed regardless of population growth. In other words, the model assumes that such investments are not attributable to land use policies or strategies such as these found in the State Development and Redevelopment Plan.

The model also assumes that a municipality would provide for the future education of its pupils using the same school districts its students attended in the 1988-89 school year. This assumption may not reflect actual future decisions.

C. Data Base for the Current Model

Data used in this model were primarily collected from the New Jersey Department of Education. Enrollments by grade level, organization of the district's facilities, and school sending

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[3] As recorded in the Forty-Eighth Annual Report (1985) of the Division of Local Government Services, Department of Community Services, Statement of Financial Condition of Counties and Municipalities.

and receiving zones[4] were determined from data collected from the " Application for State School Aid" completed in the fall of 1988. Capacity information was collected from a 1985-86 survey titled "Summary of School Building Capacity by District Grade Level Organization." Additional facility information was derived from the New Jersey Department of Education publication 1988-89 School Directory and from the Department's Annual Report.

Where information gaps existed, OSP collected the missing information by direct telephone contact and/or by follow-up letter and questionnaire. The enrollment and facility files incorporated in the model represent a 100% survey. Appendix A provides information on school district organization from the Annual Financial Report. Appendix B displays samples of each of the three questionnaires from which data were compiled. Appendix D reports the results of this data collection exercise: student enrollment, grade level organization, and capacity data for all districts in the state.

II. MODEL DESCRIPTION

Diagram 1 illustrates the four-step process incorporated in the school model.

Diagram 1

SCHOOL IMPACT MODEL DIAGRAM

Given:	MUNICIPAL POPULATION FORECAST
Step 1	FORECAST OF PUBLIC SCHOOL POPULATION
Step 2	ASSIGNMENT OF PUBLIC SCHOOL STUDENTS TO SCHOOL DISTRICTS
Step 3	COMPARISON OF DISTRICT ENROLLMENT TO FACILITY CAPACITY - COSTING OF NEEDED NEW FACILITIES
Step 4	ASSIGNMENT OF SCHOOL DISTRICT FACILITY COST TO MUNICIPALITIES
Results:	TOTAL MUNICIPAL CAPITAL COSTS FOR NEW SCHOOLS

[4] Sending and receiving zones refer to the practice of a municipality sending some or all of its students to a school district with which the municipality does not have a formal, long-term agreement (i.e. to send students to schools outside their district)

In step 1, the number of school-aged children in each county is derived from the forecast of total statewide growth. The number of students attending public schools is identified by using a constant based on the 1980 Census. The result of this step is an estimate of the total number of public school children, by age cohort, in each of New Jersey's 21 counties.

The second step assigns this future school population to school districts, in proportion to the ratio of district service population to total county population. It is assumed that school districts will serve the same municipalities they served during the school year 1988-89.

Step 3 sums the total student population by grade organization (elementary, middle, high) and compares this "demand" to the district's relevant capacity. Maintaining a facility's grade organization identity us important, since extensive renovation would be required to convert a facility's service target (i.e. convert a primary school to serve high school students). Where additional space is needed, the model estimates the capital cost for this space. The result of this phase of the program is total new facility costs by grade level organization for each school district in the state.

Step 4 assigns these totals costs to the municipalities who send their students to these districts. The cost assignment is proportionate to the ratio of each municipality served by that district. Cost for each grade level organization is summed to yield the total facility cost assigned to each municipality.

III. MODEL EQUATIONS

A. Step 1: Estimate of Public School Students by County

The model requires that the user provide a statewide set of municipal population forecasts. Such forecasts can be the result of user entered estimates or the model can use municipal forecasts developed by the OSP population/employment distribution model.[5] County population totals are multiplied by cohort factors to yield an estimate of the total number of children in each following age cohorts:

Table 1
Age Cohorts Used in the Model

Age of Students
5 to and including 11
12
13
14
15 to and including 17

[5] Office of State Planning Technical Report, Distributing Population and Employment Forecasts to Municipalities, February 1990.

The cohort factors were derived from various statewide forecasts and are specified to each county and specific to the forecasts years of 1985, 2000, 2005, and 2010. Where the model "knows" the identity of the statewide forecast, the cohort distributions used in the model were derived from that forecast. If the forecast identity is not known, as would be the case for a user-entered set of population forecasts, the model uses cohort factors developed from the New Jersey Department of Labor's Economic Demographic Model's projections. The result is a forecast of total number of children by age cohort for each county in the state.

The model then estimates the number of students who would attend public school. To determine the public school participation rate, first the age cohort populations for each county were found in the 1980 Census of Population.[6] Public school enrollment in 1980 was obtained from New Jersey Department of Education data.[7] For each county, the percentage of the population in each school-age cohort attending public schools in 1980 was calculated; these percentages are then held content for all future years.

The resulting algorithm for this step in the model is as follows:

Public School Student Algorithm

TCP x % FCP 5-11	x % PS = PSC
TCP x % FCP 12	x % PS = PSC
TCP x % FCP 13	x % PS = PSC
TCP x % FCP 14	x % PS = PSC
TCP x % FCP 15-17	x % PS = PSC

TCP = total future population for any New Jersey county
% FCP 5-11 = percentage of TCP in the defined age cohort - for example, ages 5 -11
% PS = percentage of % FCP (cohort) that attended public Schools in 1980
PSC = number of future public school students in that age cohort

The derivation of public school multipliers by county is shown in Appendix C of this report.

B. Step 2: Estimate School District Enrollment

Data collected from the New Jersey Department of Education and, where necessary, completed by OSP, identify which school districts served each municipality during the school year 1988-1989. The data also reveal school grade organization for each district. Several grade organization combination were noted, as shown in Table 2:

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[6] Characteristics of the Population, General Population Characteristics New Jersey, Tables 18 and 46
[7] New Jersey Public School Enrollment by County District, Grade, Sex, published September 30, 1980.

Table 2
Alternative Grade Organization (1988 - 1989)

Grade Organization	Actual Grades
elementary	K-3
elementary	K-4
elementary	K-5
elementary	K -8
elementary	K-6
elementary	K- 7
middle school	4-8
middle school	7-8
middle school	4-9
middle school	5-8
middle school	6-8
middle school	4-6
middle school	7-9
middle school	4-7
high school	9-12
high school	7-12
high school	8-12
high school	10-12

Source: New Jersey Department of Education, New Jersey Public School Enrollment.

The age cohorts analyzed in this study are part of an attempt to make sure that future student assignments are consistent with the current grade level organizations in each district. Since students in the 12 to 14 year-old age cohorts can be in many different types of schools (elementary, middle, high), it is important to break these cohorts out separately. In order to better match future cohorts to each district's current grade organization, the following age-to-grade assignment assumptions were made in the model:

Table 3
Age to Grade Assignment Assumptions

age cohort	grade assigned
5-11	K-6
12	7
13	8
14	9
15-17	10-12

Given each district's definition of elementary, middle, and high schools, the assignments shown in Table 3 permit more accurate matching of student population to the relevant facility type.

Municipal and school district boundaries are not coterminous. In order to deal with specific elementary, middle or high school needs in each district, it was necessary to develop the concept of service population. Service population is defined as the total population in -- or sending to -- a district serving a specific grade level. For example, if Podunk Township, N.J. had a population of 100 persons and sent its elementary student to the Podunk School District, which only served Podunk, then the service population of the Podunk School District would be 100 persons. If Podunk sent its high school students to Greater Podunk Area Regional High School, which also served Smallville, then the high school's service population would be the sum of the population of Podunk and Smallville. Grade-level and service population relationships are held constant in the model at the 1988 status quo.

The concept of service population is used in the model two ways: 1) it is used to "grow" the existing district student population for a particular facility type under the assumption that the number of (say, middle school) students will constitute the same proportion of the relevant service population in the future as they have in the past; 2) it is used in Step 4 to distribute cost back to municipalities.

The following algorithm illustrates the first of these uses -- to estimate future school district enrollment by grade organization:

Public School Enrollment Algorithm
(example is for middle schools)

$$\frac{MS88}{MPOP88} \times MPOPtt = RMStt$$

Where MS88 = district middle school students in 1988
MPOP88 = middle school service population in 1988
MPOPtt = middle school service population in target year
RMStt = raw forecast of district middle school students in target year

This equation has the advantage that it carries forward existing definitions of elementary, middle and high schools in each district. For example, a population served by a high school district with grades 10 to 12 would have allowed proportion of high school serving grades 8 through 12. The equation above handles this type of difference automatically.

The drawback of this equation is that it may produce student populations that conflict with demographic projections at the county level. A second equation corrects for this by controlling district students to the relevant county cohort forecasts:

Public School Enrollment Algorithm -- Part II
(again, example is for middle schools)

$$\frac{CMStt}{CRMSTT} \times RMS = \text{final forecast of middle school enrollment for a specific school district in target year}$$

where
CMStt = total county public school population in relevant (middle school) age cohort in target year
RMStt = raw middle school students calculated above
CRMStt = sum of all raw middle school students forecast for districts in the county in target year.

The methodology for forecasting future student populations attempts to deal with a highly complex set of overlapping jurisdictions and forecasts. Some methodologies that were used to handle special cases may not be reflected above. For example, the second equation above had to be adapted in a case where a school district straddles county boundaries. We have made every attempt to use the most detailed information available, in order to accurately compare future student populations to relevant capacity.

C. Step 3: Comparison of Need to Capacity & Cost Estimation of New Facility

Future student enrollment by grade organization, calculated in the preceding step, is compared to the district's definition of building capacity by grade organization. If future enrollment does not exceed the 1988 capacity, no capital costs are computed. If enrollment exceeds capacity, costs are calculated. This capacity analysis is independently performed for each facility level for each school district.

In the calculation of capacity, the New Jersey Department of Education facility planning staff advised OSP that this analysis had to allow for enrollment to exceed stated capacity. For example, as a school enrollment grows, the district might elect to curtail non-core curriculum programs and use space previously dedicated to these programs. Therefore, an enrollment to capacity ratio 1 or greater would be achieved. To simulate this capacity flexibility, the model requires users to select a ratio of enrollment to capacity for each facility level. This factor is then used to determine when a new facility is needed in the program. The following table lists the model variables:

Table 4
Ratios of Enrollment to Capacity

Elementary	Middle	High
.8	.8	.8
.9	.9	.9
1	1	1
1.1	1.1	1.1
1.2	1.2	1.2
1.3	1.3	1.3
1.4	1.4	1.4
1.5	1.5	1.5

Should a new facility be required, several more user determined variables act as a key elements in the costing equation. For each of these variables the user is required to make a selection for each type of school grade organization.

1. Size of Facility Created - There are numerous options available to school district to extend the capacity of school building facilities. Capacity can be added by building one or more classrooms. Many districts defer construction until the need for an entire new school building is

evident. To simulate this range of options, alternative facility sizes have been incorporated into the model.

Table 5
Alternative Facility Sizes
(Student Per Construction Increment)

Elementary	Middle	High
30	200	500
50	300	750
100	400	1000
150	500	1250
200	600	1500
300	700	2000
400	800	2500
500	900	
600	1000	
700		
800		

2. Space per student - The New Jersey Department of Education provided information concerning the reasonable range of square foot per pupil alternatives.

Table 6
Square Foot Per Pupil Alternatives

Elementary	Middle	High
90	125	150
95	135	160
100	140	170
105	145	180
110	150	185
115	155	190
120	160	195
125	165	200
130	170	205
135	175	210

3. Construction cost per square foot - The New Jersey Department of Education also provided guidance on the range of construction costs. The alternatives included in the model are:

Table 7
Construction Costs per Square Foot

Elementary	Middle	High
$ 90	$ 90	$ 90
95	95	95
100	100	100
105	105	105
110	110	110
115	115	115
120	120	120
125	125	125
130	130	130
135	135	135

While this multitude of variables might seem overly complex, the intent of the model is to allow planners to customize results to fit the circumstances likely to happen in their jurisdiction.

The following algorithm illustrates the process to determine the need for new elementary facilities. Simultaneously, other equations are examining the need for new middle and high school facilities.

Analysis of School Need Algorithm

If future elem - (Ecap x (1+EC) is less than or equal to zero, then zero
OTHERWISE Future elem-ECap

Future elem	= forecasts of student enrollment for elementary schools
Ecap	= 1988 elementary facility capacity
EC	= % overcrowding tolerated before new facility needed

This equation incorporates an assumption that once the need for a new facility is identified,[8] then a new facility would be designed to absorb new growth and eliminate overcrowding in the district's existing facility.

Once the need is determined, the cost for the new facility (s) is calculated, as shown in the example for elementary schools below:

[8] Fractional results in the actual equation are rounded up to whole numbers

School Cost Algorithm

Ebuild x elem cap x elem sq ft x elem cost x elem adjust = estimated cost of the district's new elementary facilities

Ebuild	= number of new construction increments (structures) required
elem cap	= number of students per increment
elem sq ft	= square feet of built space per student
elem coast	= construction cost per square foot
elem adjust	= regional cost adjustment variable (default is 1 used as a state constant) This also is a user select variable.

D. Step 4: Assignment of District Capital Costs to Municipalities

School district cost for each type of facility are assigned to the municipalities served by each facility type. This assignment is proportionate to the municipality's population's percentage of the total school district population. All analysis is done at a grade organization basis.

The following equation represents this cost allocation method:

Cost Allocation Algorithm

$$MC = \frac{\text{munc pop}}{\text{elemDP}} \times \text{elem cost} + \frac{\text{Mun pop}}{\text{midDP}} \times \text{mid cost} + \frac{\text{mun pop}}{\text{HDP}} \times \text{H cost}$$

MC	= total capital cost assigned to any municipality
mun pop	= total estimated future population of the municipality
elemDP	= total population served by the school district providing elementary school services to the municipality
midDP	= total population served by the school district providing middle school services to the municipality.
HDP	= total population served by the school district providing high school services to that municipality
elem cost	= total new elementary capital costs needed by the district supplying elementary service to the municipality
Mid cost	= total new middle school capital costs needed by the district supplying middle school service to that municipality
H costs	= total new high school capital costs needed by the district supplying high school services to that municipality

The result of the model is the total school facility capital cost estimate for each municipality.

IV. FUTURE RESEARCH OPTIONS

In this section, we will discuss extensions, enhancements, and applications of the Schools portion of the Fiscal Impact Model.

A. Refinements to the Model

The model represents a comprehensive method of estimating the costs of constructing schools facilities under alternative growth scenarios. However, several refinements to the model are being considered.

1. Added cohort differentiation - Currently school aged populations are estimated for five age groups (5-11, 12, 13, 14 and 15-17). While this allows for reasonably good age to facility assignments, the estimation of children by individual years might enhance the student assignments.

2. Include all schools in analysis - Costs projected in the current model reflect the need for new elementary, middle and high schools. Although the data exist, the model does not estimate costs for special education or vocational school facilities.

3. Provide alternative methods to estimate public school participation - The model now assumes that the same percentage of students that attended public school in 1980 will attend public schools in the future. Data on public/private school enrollment in 1988 are now available. One could also imagine a methodology that projects private school enrollment using the 1980-88 trend or projections of local income.

4. Assign capital costs to municipalities by property value, not population - This is how school district costs are assigned in reality. The Operations portion of the OSP computer model projects future assessed value, but it does so on a per-capita basis.[9] These two components of the model should be linked for purposes of assigning school district costs.

B. New Applications

The model can be used to test the cost implications of alternative student/teacher ratios. The model could be adapted to test the efficiency of alternative service areas and/or districts.

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[9] See OSP Technical Report Projecting Operating Budgets under Alternatives Growth Scenarios.

Appendix A -- Organization of New Jersey School Districts 1984-85

(not included in electronic version)

Appendix B -- Questionnaires used to Obtain Enrollment and Capacity Data

(not included in electronic version)

Appendix C -- Public School Enrollment by County, 1980

(not included in electronic version)

Appendix D -- Table of Enrollment and Capacity by District, 1989-90

(not included in electronic version)